

# USNA Satellite Lab/Ground Station

Bob Bruninga, Ground Station  
Engineer

- Satellite and communications Labs
- Satellite Design Projects
- Ground Station Operations
- Extracurricular

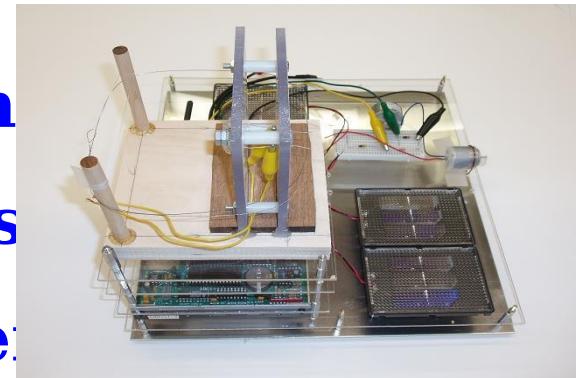
April 2006



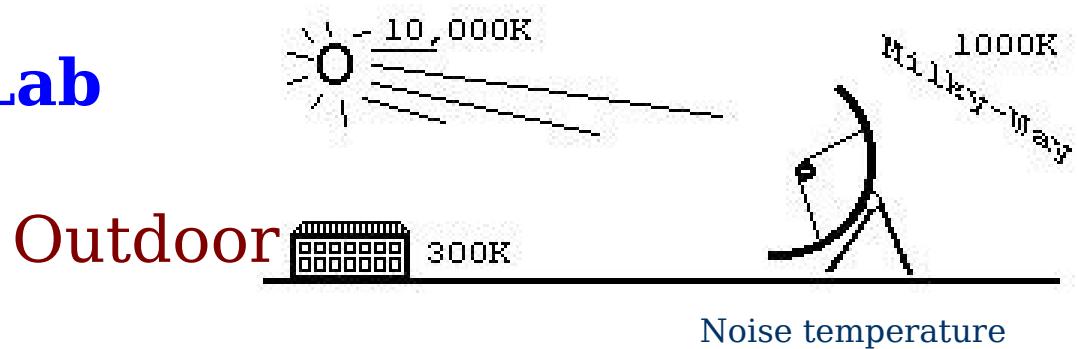
RAFT & MARScom

# Satellite Labs

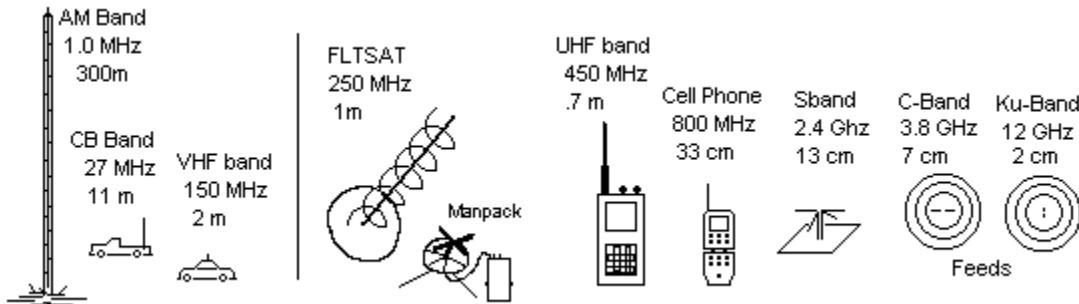
- **Communications, Links, An**
- **Communications, Receivers**
- **EPS, Electrical Power System**
- **Signals and Telemetry**
- **Thermal Lab**



Indoor

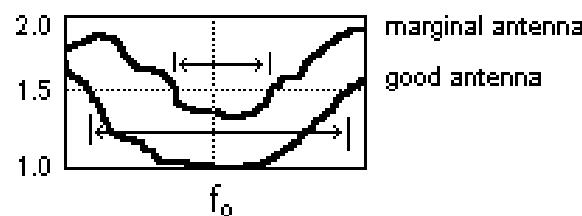
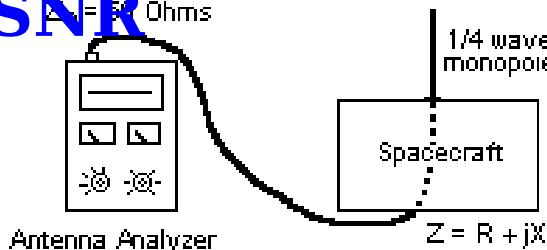


# Communications, Links, Antennas



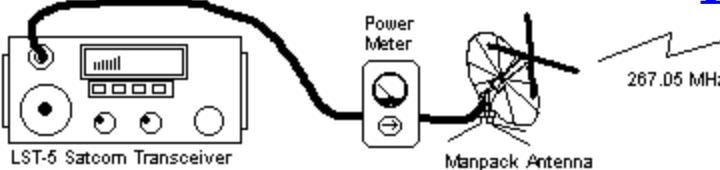
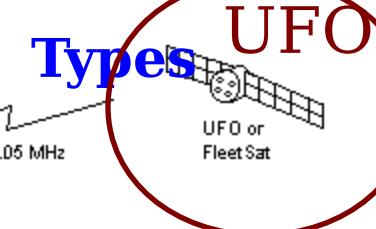
**Gain,  
Beamwidth  
Link Budget**

**SNR**



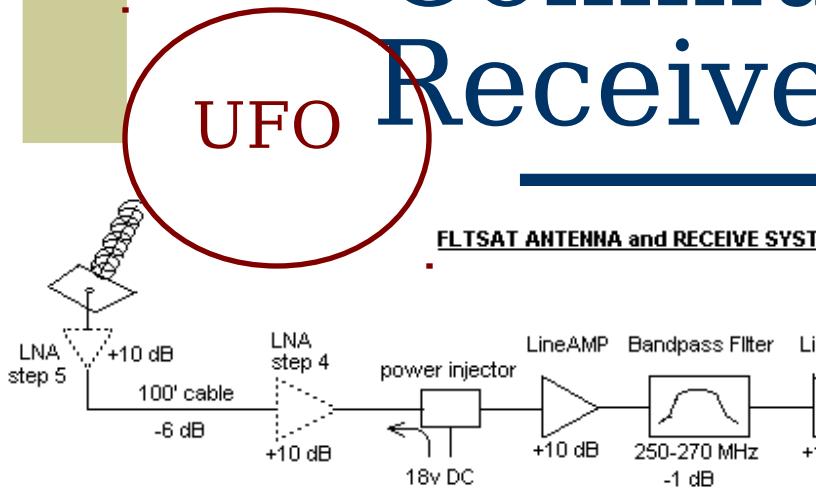
**Wavelength**

**Antenna  
Size**



**SWR  
Matching**

# Communications, Receivers, Losses

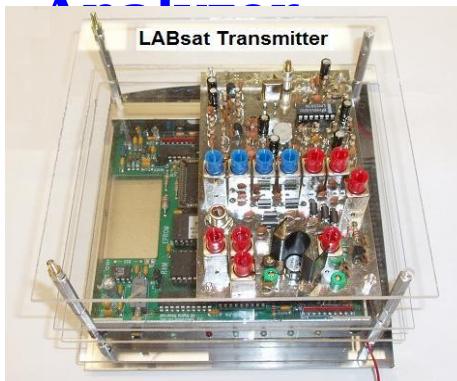


Geo-Arc

Beamwidth

Spectrum

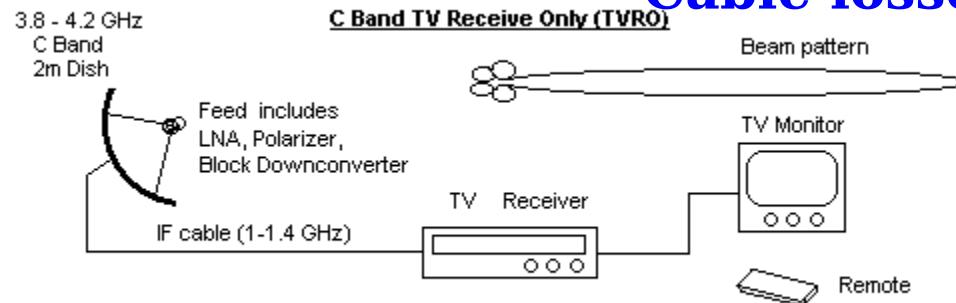
Amplifiers



Gain, losses

Amps and  
LNA's

Cable losses

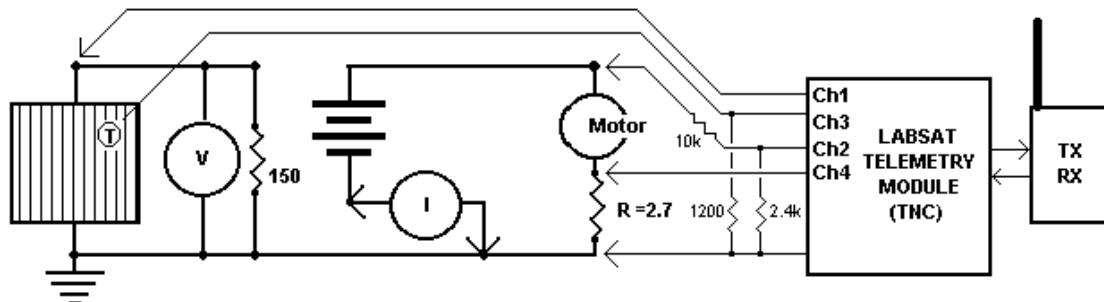


Downconverters

Demod,  
Decoding



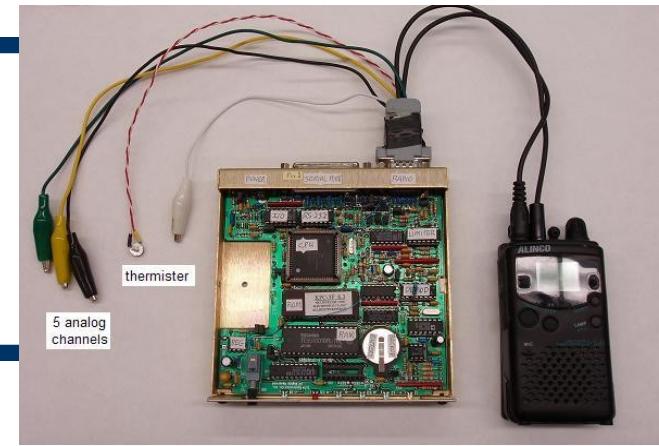
# EPS Lab



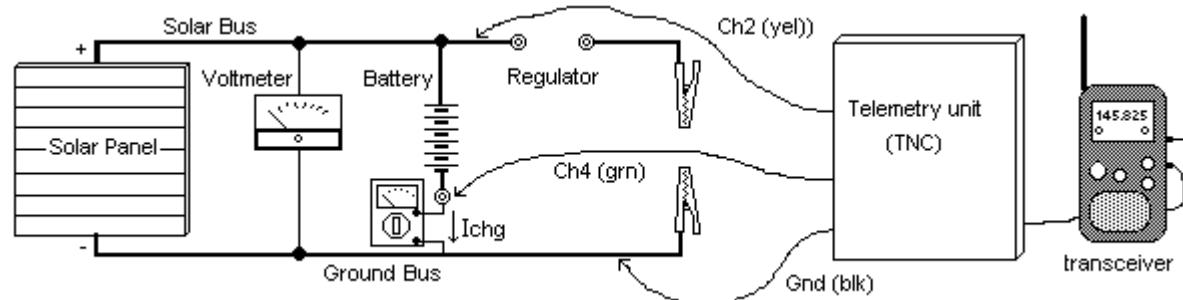
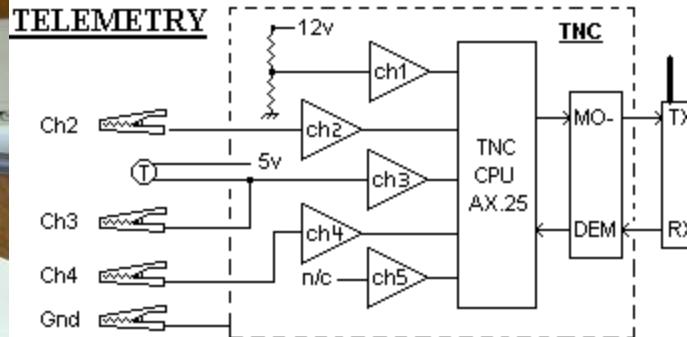
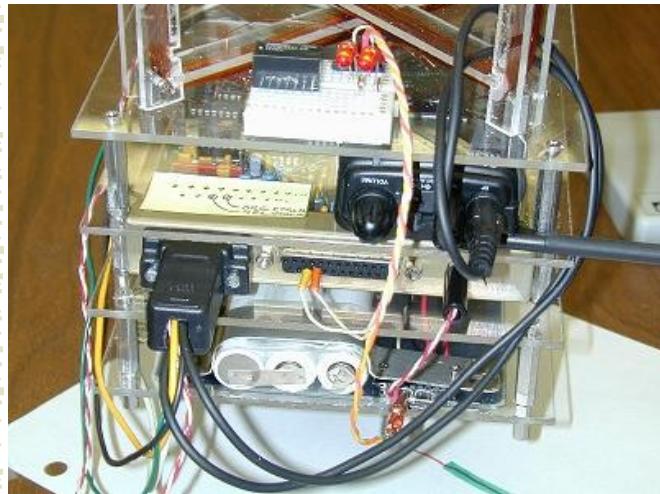
EPS  
LABsat  
Design Lab

**Solar  
Panels**  
**I-V curves**  
**Distributio  
n**  
**Regulation**  
**Shadowing**  
**RTG demo**

# Telemetry Lab

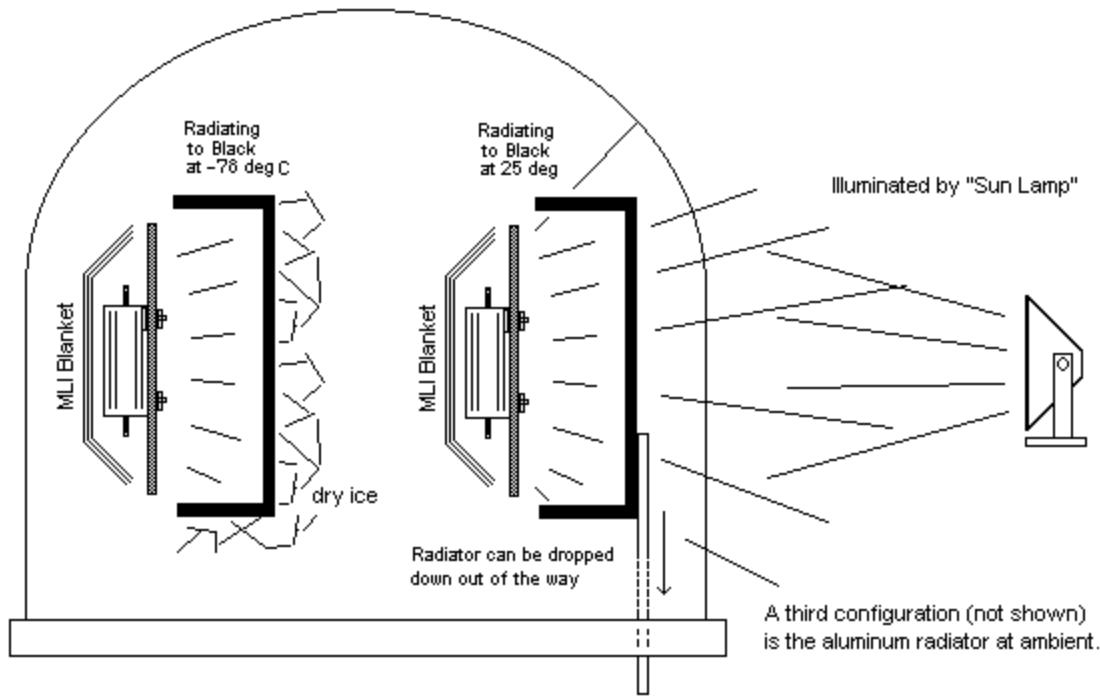


Telemetry / Command and Control System and RF Transceiver



**Sensors**  
**Circuits**  
**Conditioning**  
**Engineering**  
**conversion**  
**Decoding**  
**Protocols**

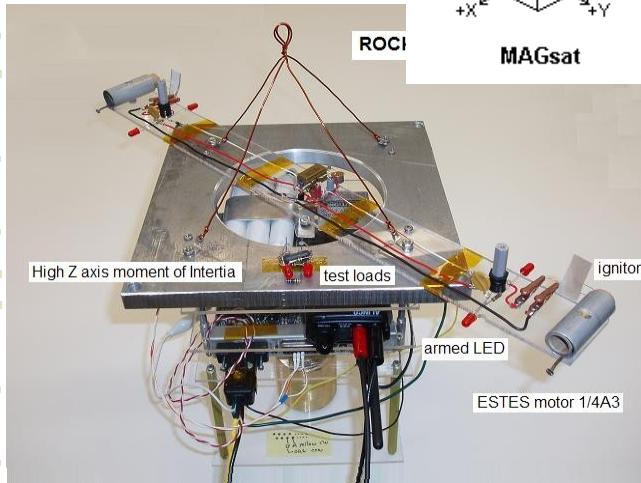
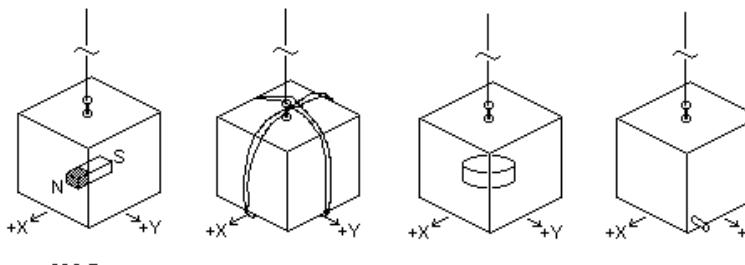
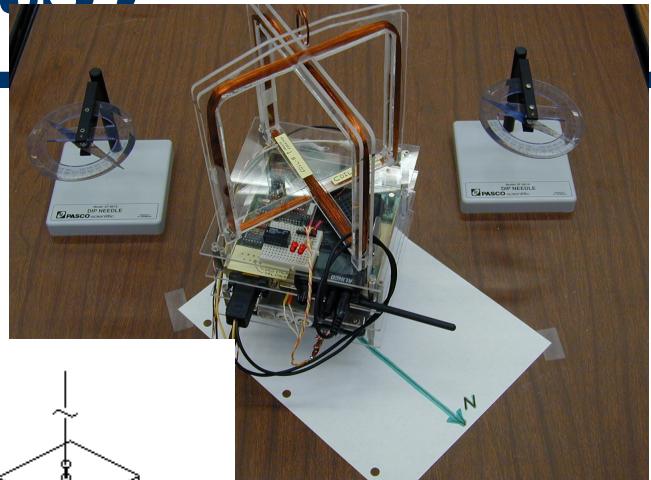
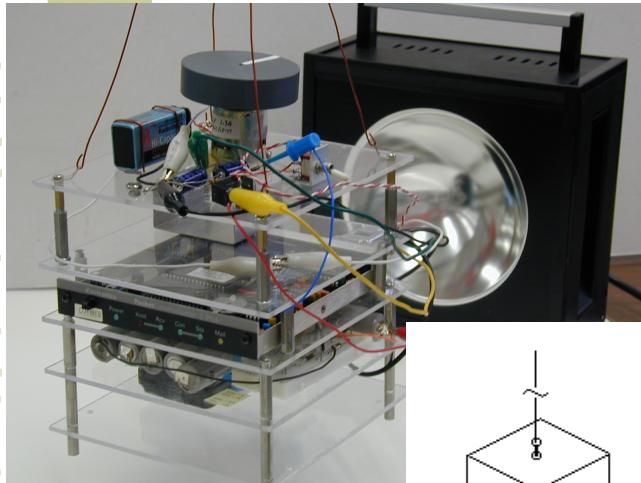
# Thermal Lab



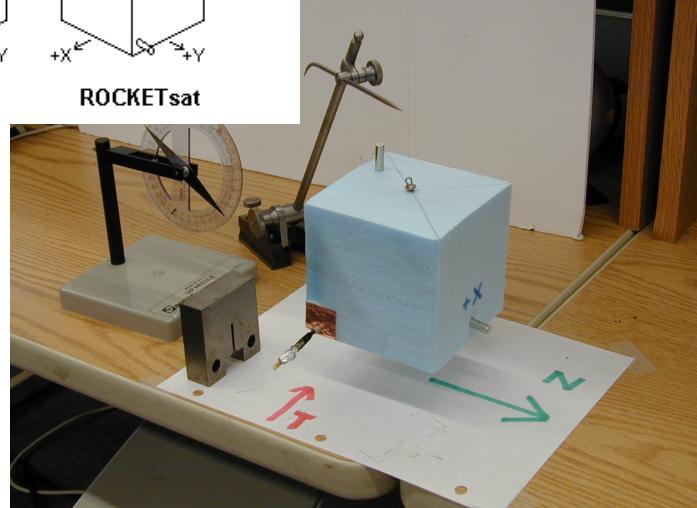
**Conducti  
on**  
**Radiation**  
**Absorbtiv  
ity**  
**Emissivit  
y**  
**Insulatio  
n**

Hope to make this LABsat-based this Fall

# Attitude Control Labs (LABsats)



Can  
demo all  
but  
gravity  
gradient



# USNA Satellite Lab/Ground Station

Bob Bruninga, Ground Station  
Engineer

- Satellite and communications Labs
- Satellite Design Project
- Ground Station Ops
- Papers & Presentations
- Extracurricular

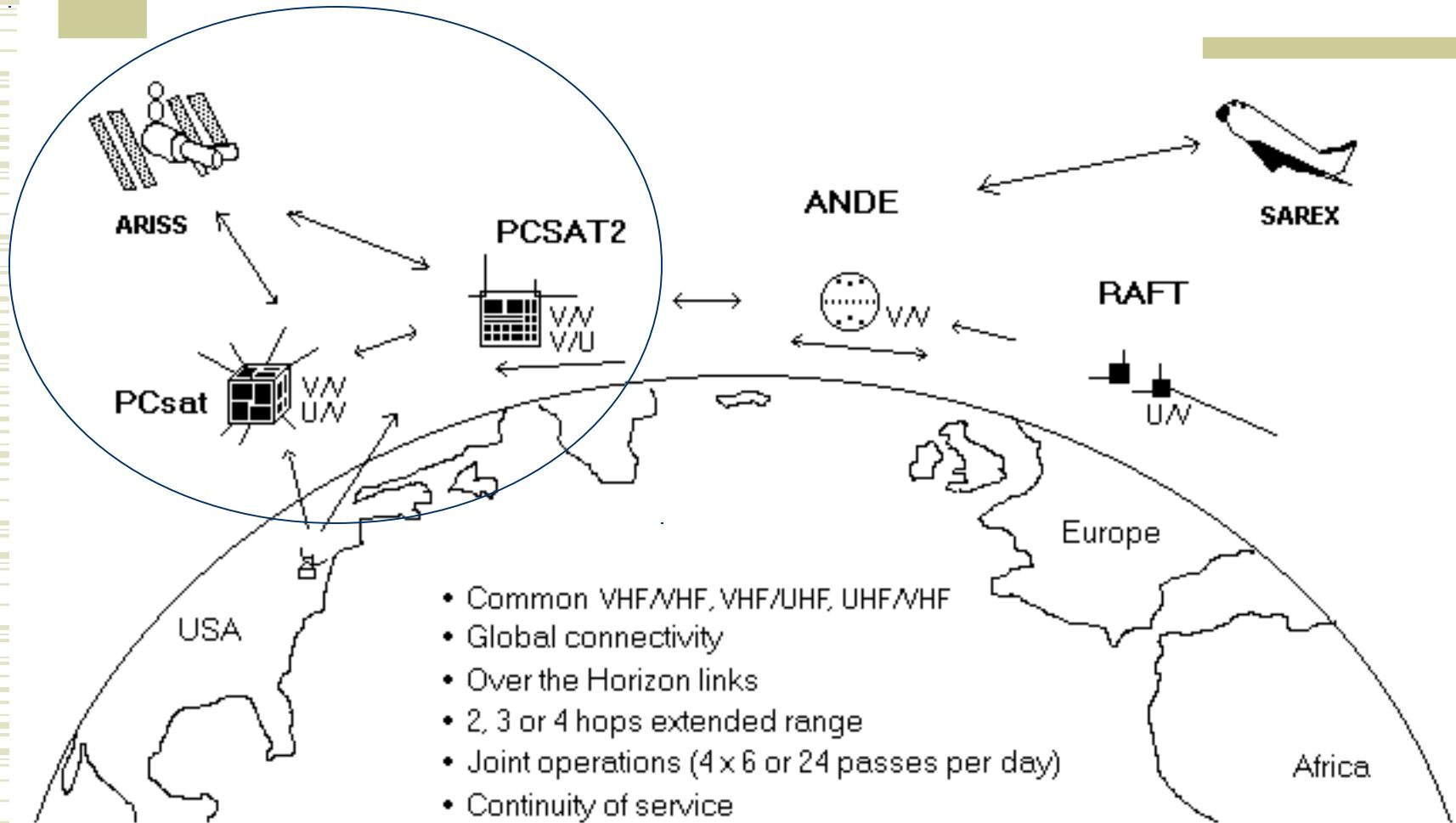


**USNA  
SATELLITES**

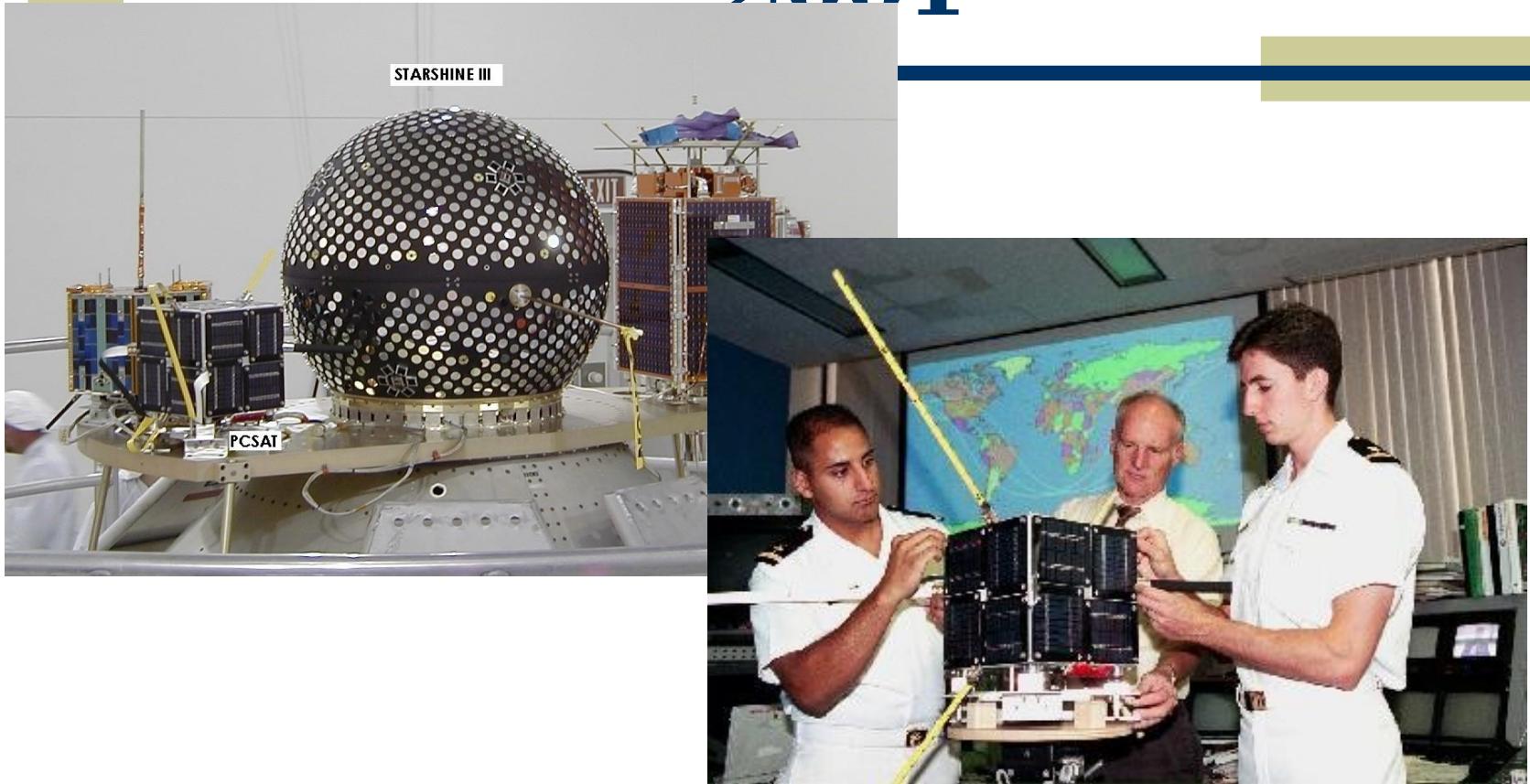
# Satellite Design Projects

- **NATSwеб** – 1<sup>st</sup> Sea-Launch (scrubbed in last week!)
- **PCsat** – **Launched** 30 Sept 2001
- **Sapphire** -- **Launched** 30 Sept 2001
- **PCSAT2** – **Launched** 26 Jul 06 return to flight
- **ARISS** 2003 – **Launched** on Progress Aug
- **ANDE** – **Manifest.** STS-116
- **RAFT1** – **Manifest.** STS-116
- **MARScom** – **Manifest.** STS-116
- **ParkinsonSAT** – Commenced Spring 2006

# USNA Constellation



# PCsat, launched 30 Sept 2001



Team: 6 Students, 2 Profs, 1 Engineer  
Over 2200 mobile Amateur Satellite Users

# PCsat Mission

# Data Relay (Situational Awareness) for Mobiles and Handheld radios. GPS



# Typical PCsat User Station



# Typical Pass Display



MAP display of APRS stations seen on-the-air

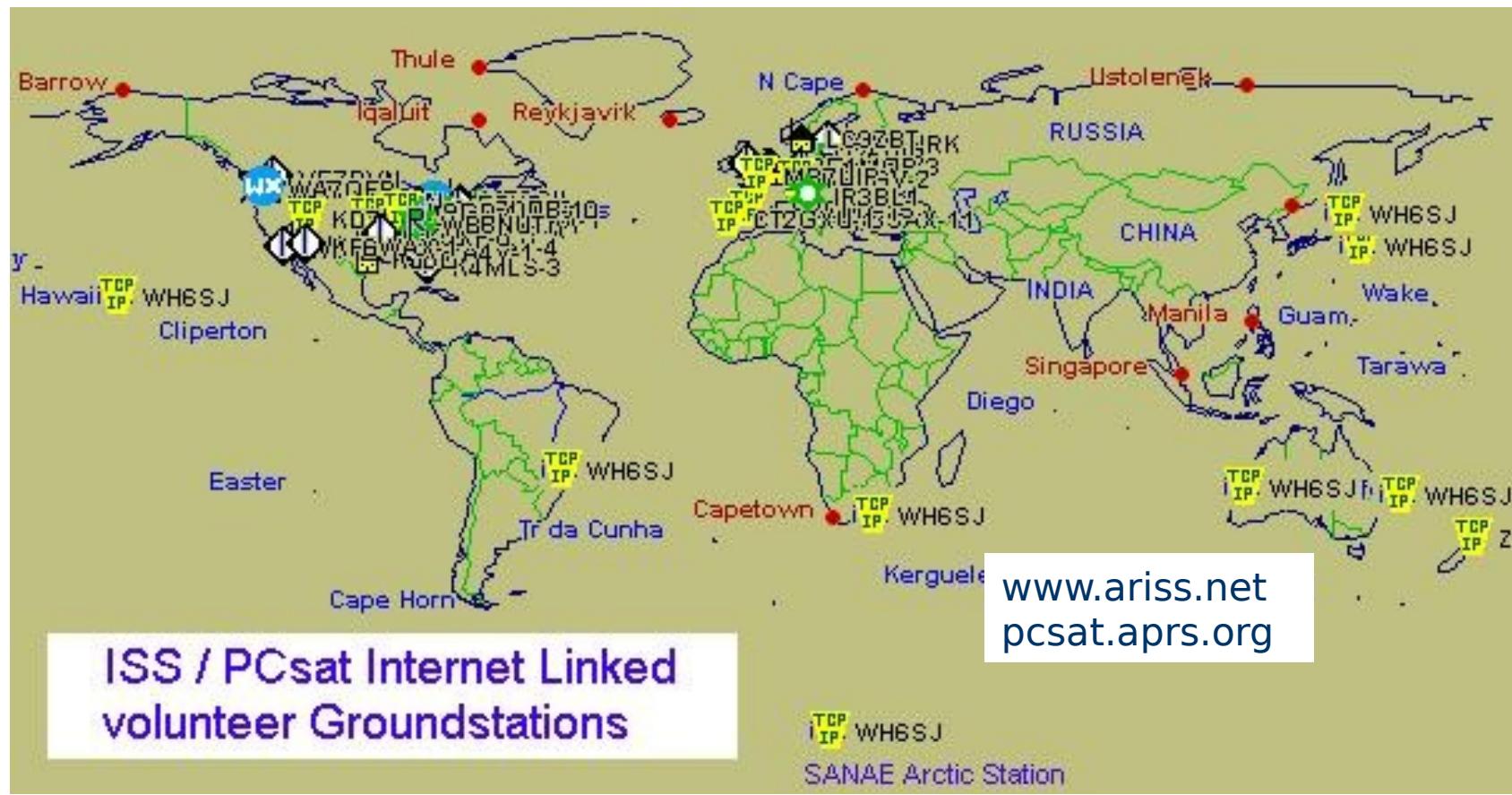
Map shows current position of all satellites

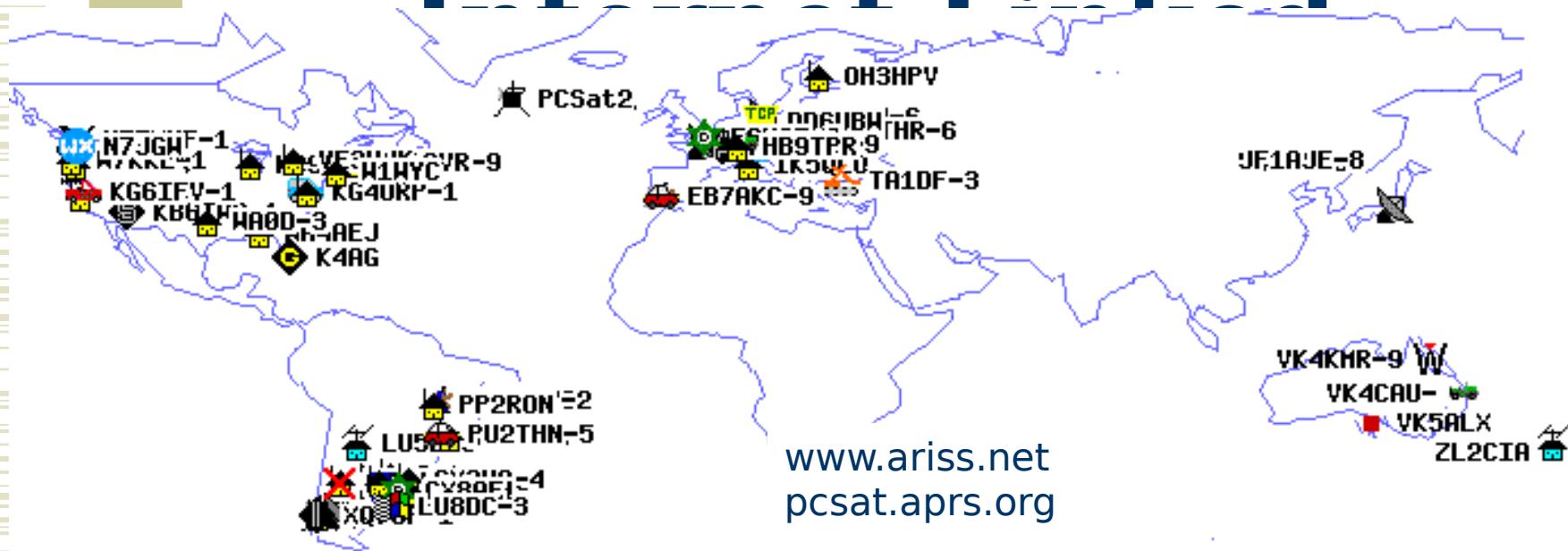
Rings show EL angle from own station

Next 2 hours of Passes. Shows max EL angle

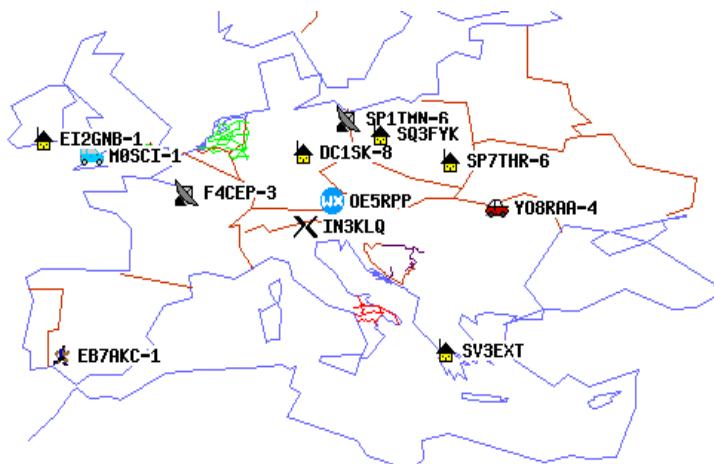
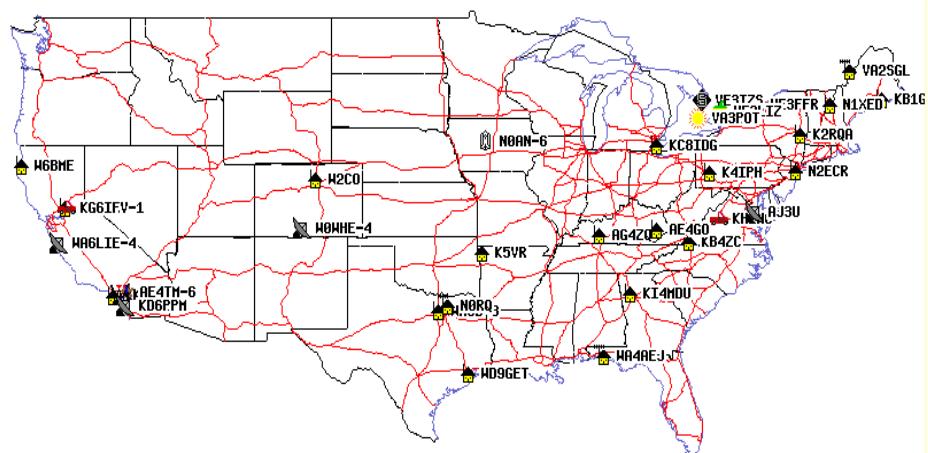
All satellites are shown on the map as moving objects. Across the bottom of the screen the next 2.5 hours of satellite passes are shown in a graphic showing the maximum elevation of the pass.

# Internet Linked Ground Stns

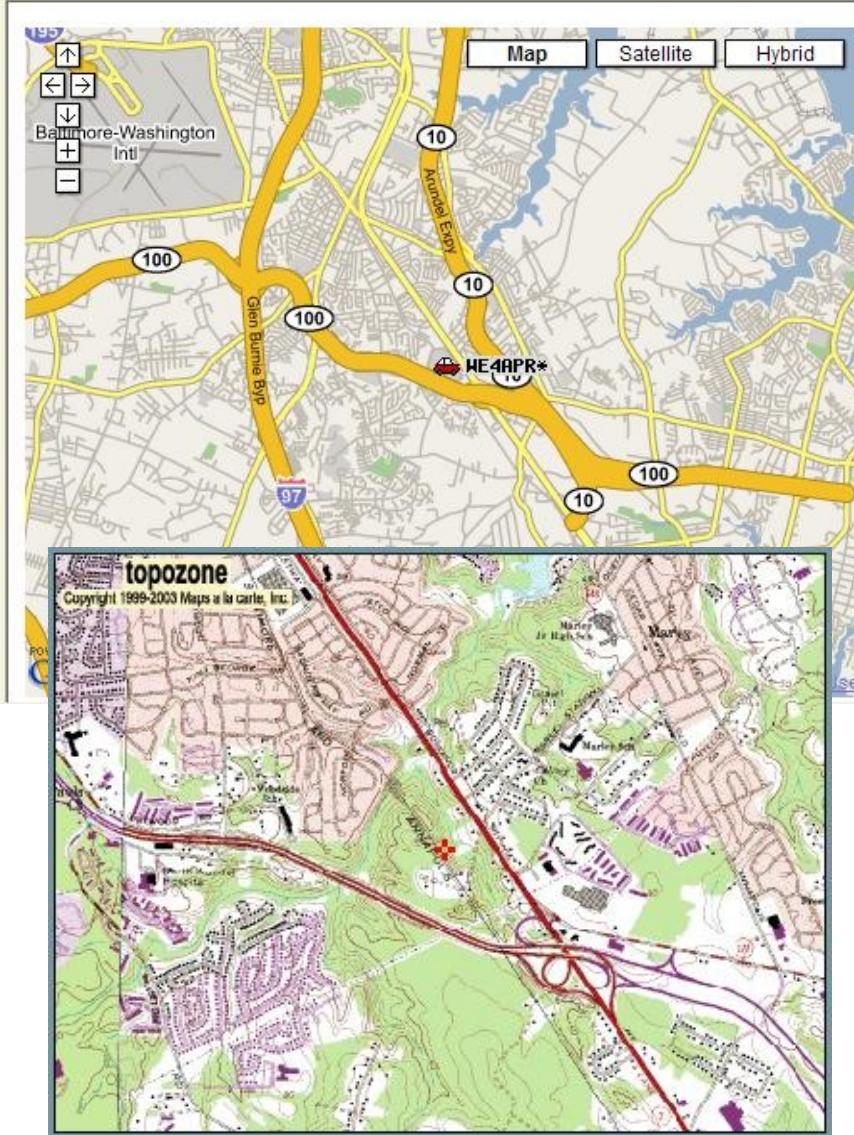




[www.ariss.net](http://www.ariss.net)  
[pcsat.aprs.org](http://pcsat.aprs.org)



# Internet Linked Data Displays



[www.ariss.net](http://www.ariss.net)  
[pcsat.aprs.org](http://pcsat.aprs.org)

# PCsat “Student Operations”



# Other Experiments through PCsat

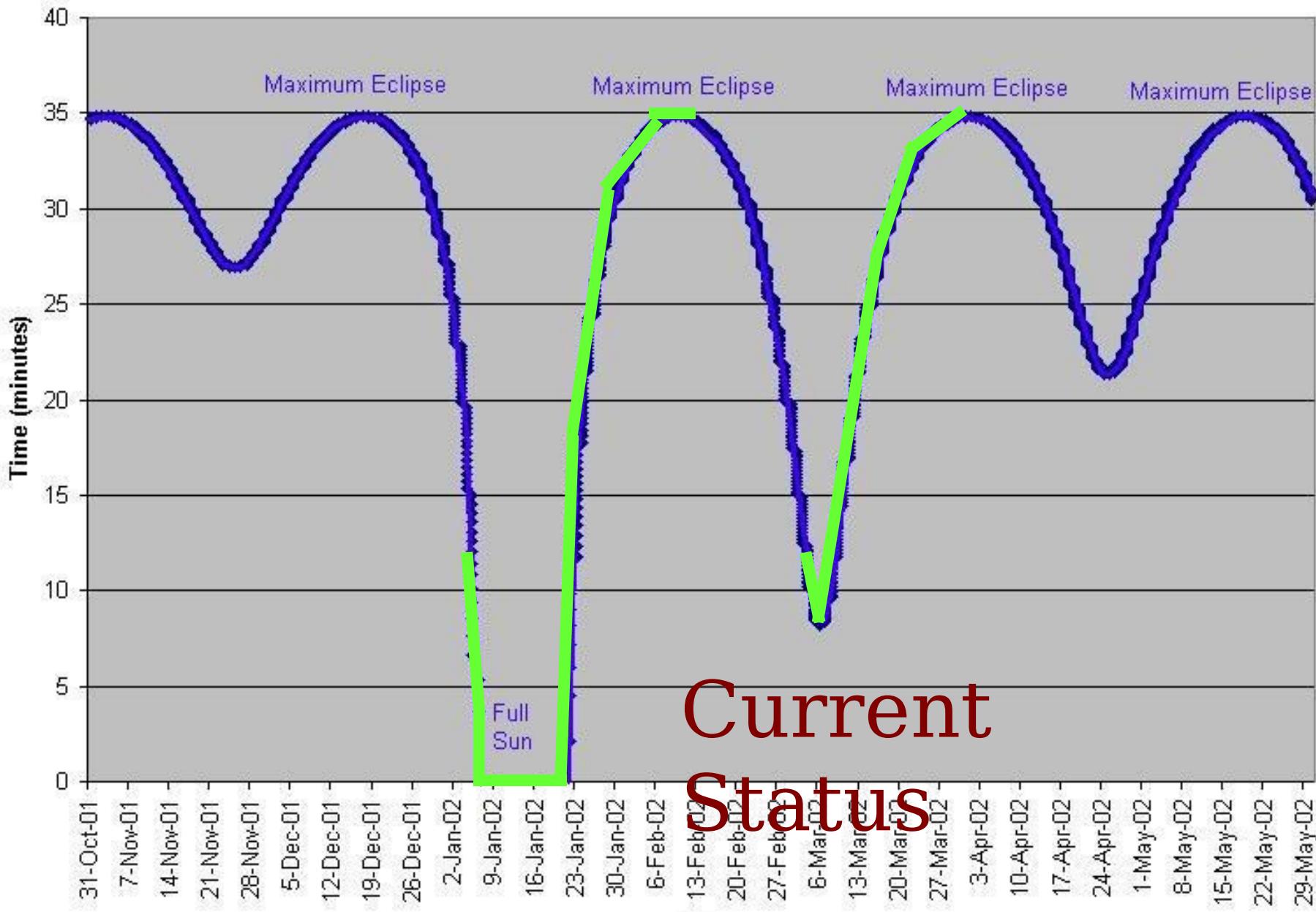


The Flashline Mars Arctic  
Research Station (FMARS)  
2002 Field Season



- **Antarctic WX station**
- **F-16 downed flyer demo** (Rome Air Development Center)
- **Arctic Tracking** (trucks up frozen rivers  $>70^{\circ}$  Latitude)
- **ISS Joint Ops** (2 weeks of constellation flying)
- **USNA Marconi Re-enactment** (St Johns Newfoundland)

# PCsat Eclipse Times in Minutes



# Air & Space Museum

Donated April 2004 to  
Smithsonian



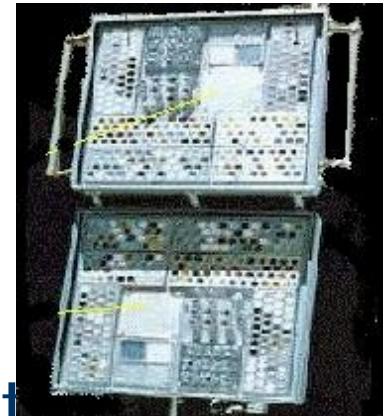
# PCSAT2, DOD synergy in the Amateur Satellite Service

Bob Bruninga

US Naval Academy Satellite Lab

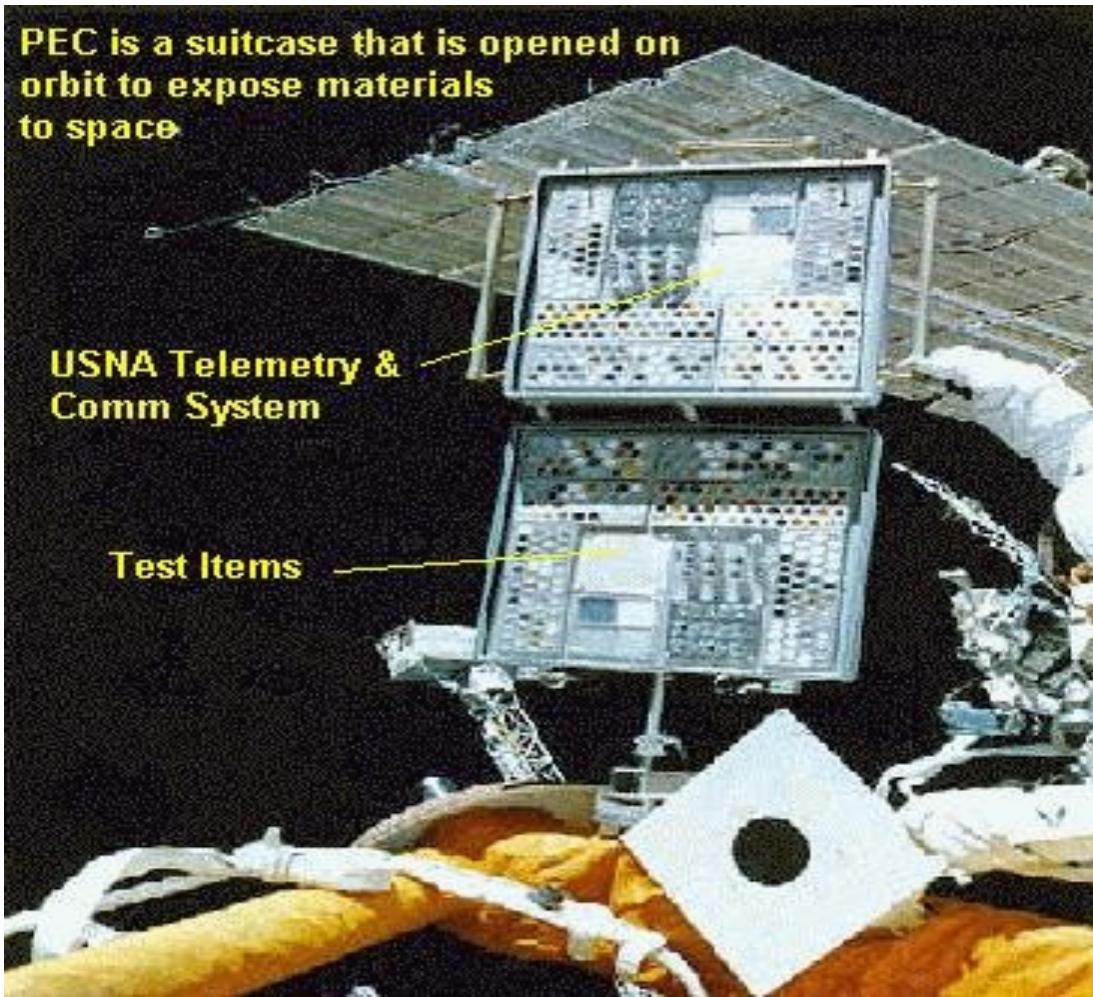
## Amateur Satellite Service partnering with DOD and ARISS

- ◆ Very short development time
- ◆ Simplicity and off the shelf
- ◆ Educational Project
- ◆ Usable communications service to  
Users
- ◆ Telemetry for Space Environment
- ◆ Configuration controlled on the ground



# DOD MISSE5 Opportunity

Passive Experiment Container - PEC

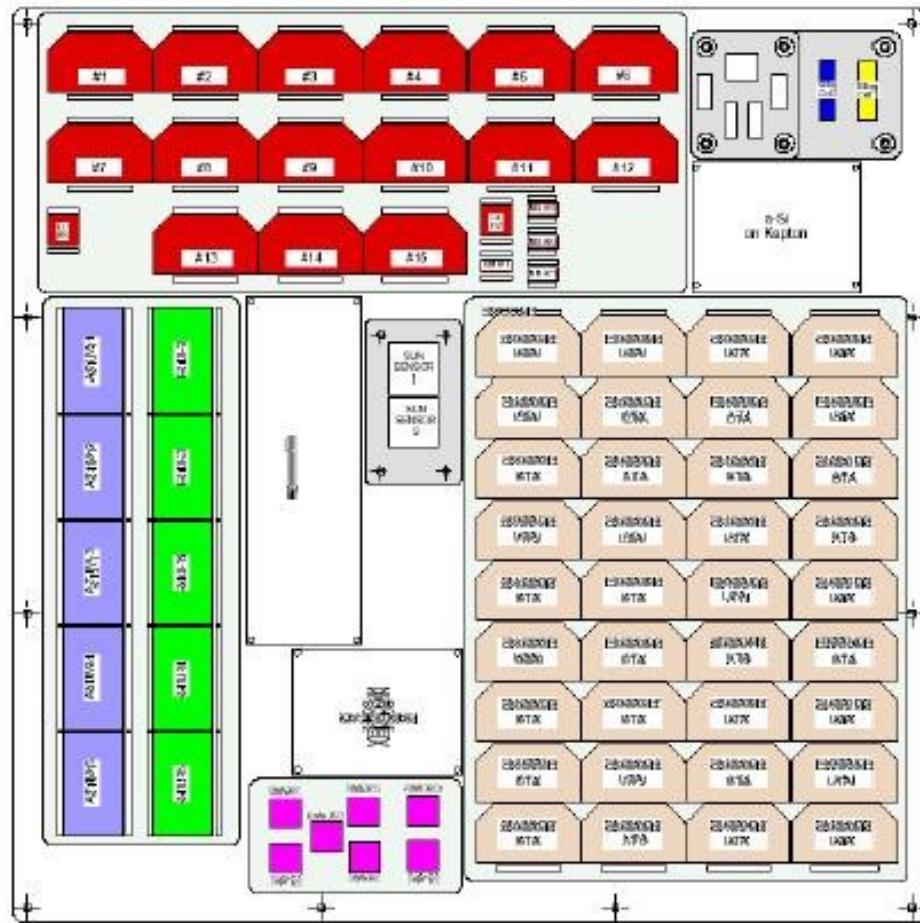


25" square by 6" thick Suitcase

Opens to expose samples to space

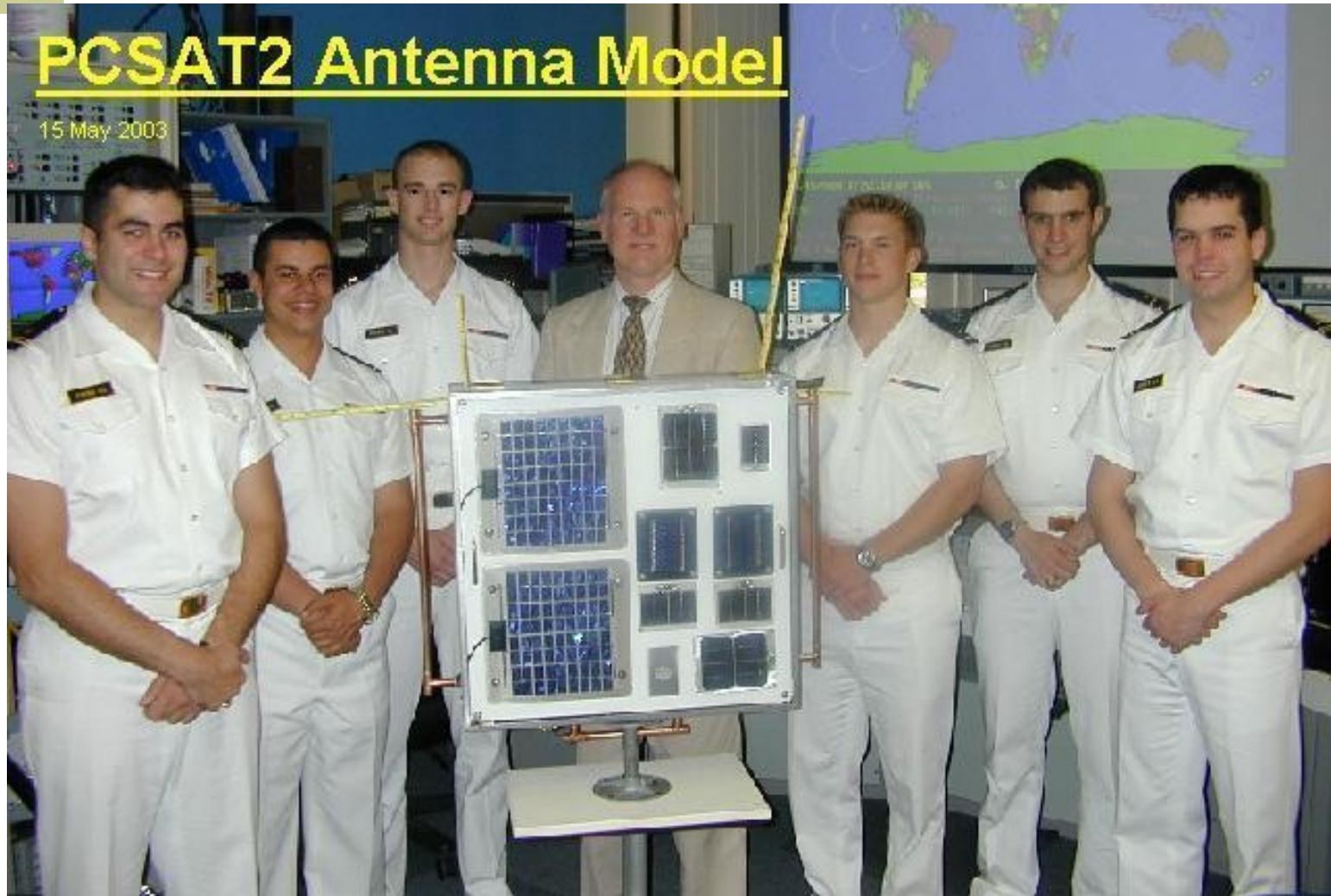
We got back

# NASA/Glen Solar Experiment



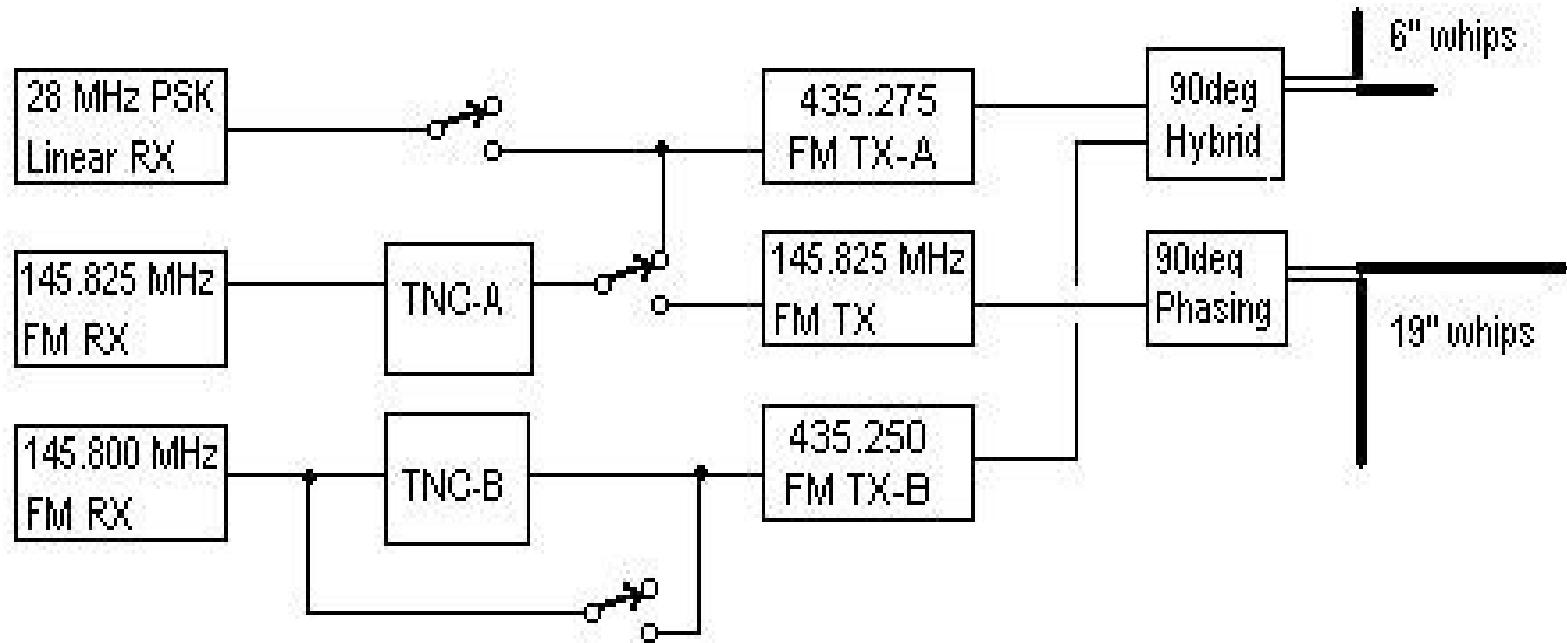
**40 Solar Cell Samples**  
**Latest triple junction technology**

# The PCSAT2 Student Team



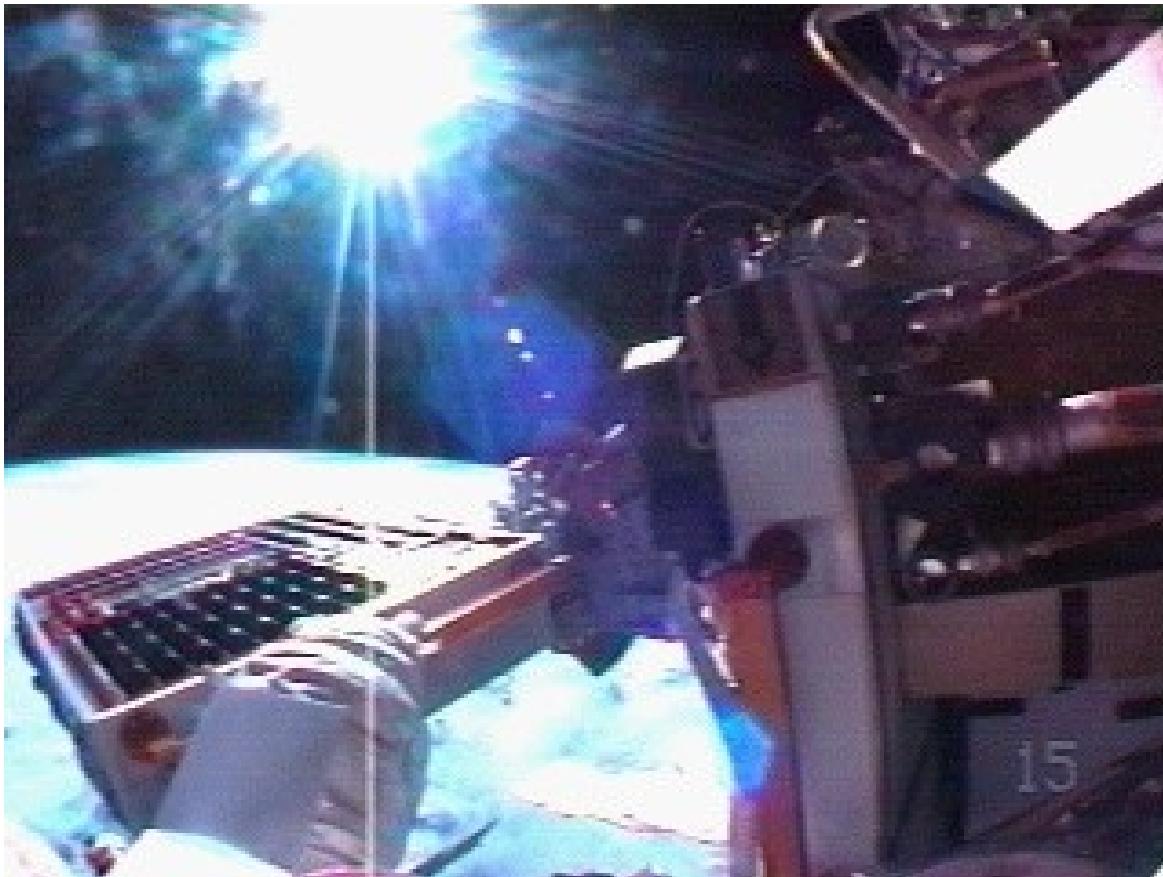
# Satellite Transponders

## PCsat2 COMMS FUNCTIONAL BLOCK DIAGRAM



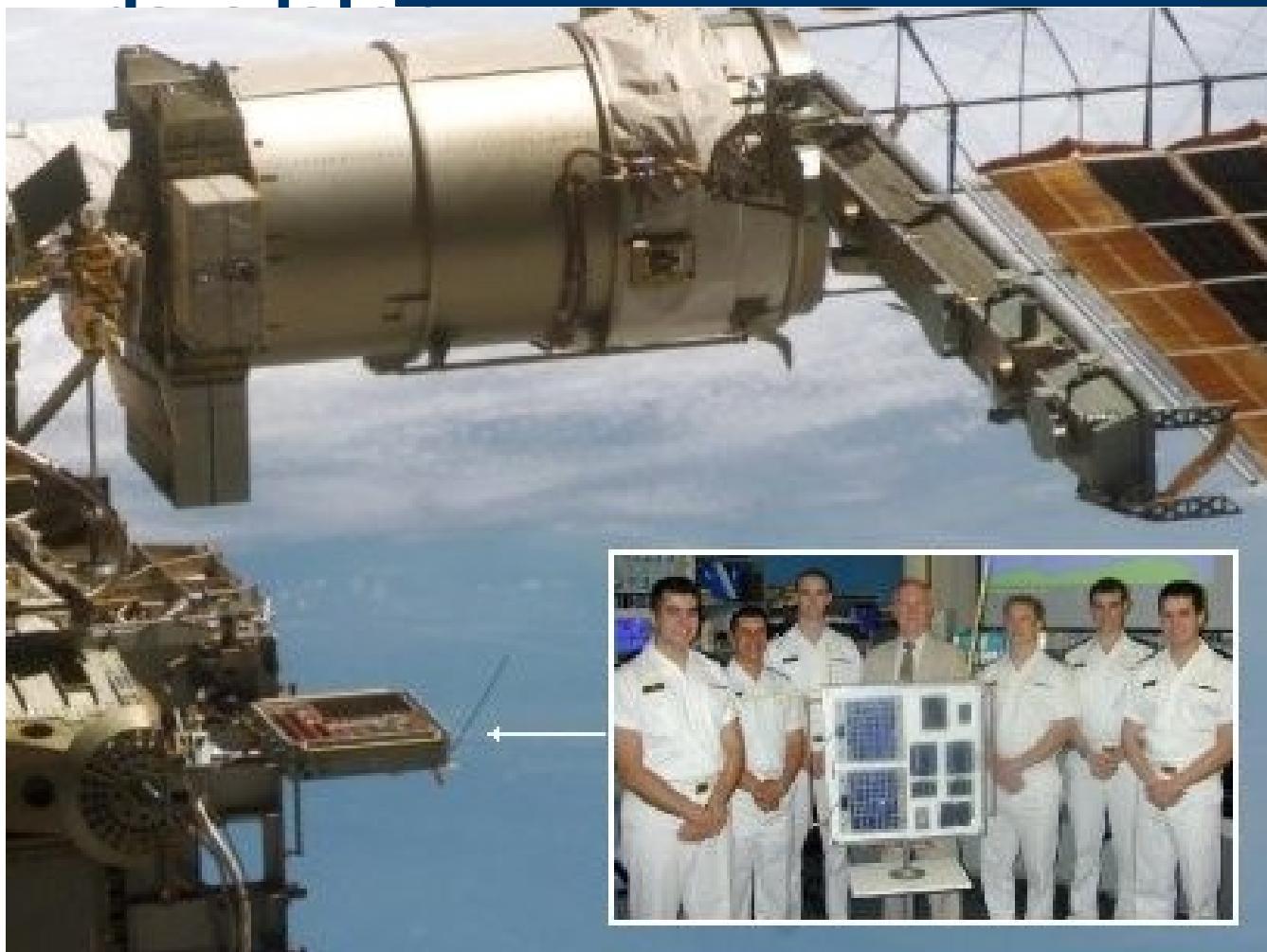
# PCSAT2 on ISS

Launch 26 July 2005!    EVA-installed 8  
days later.



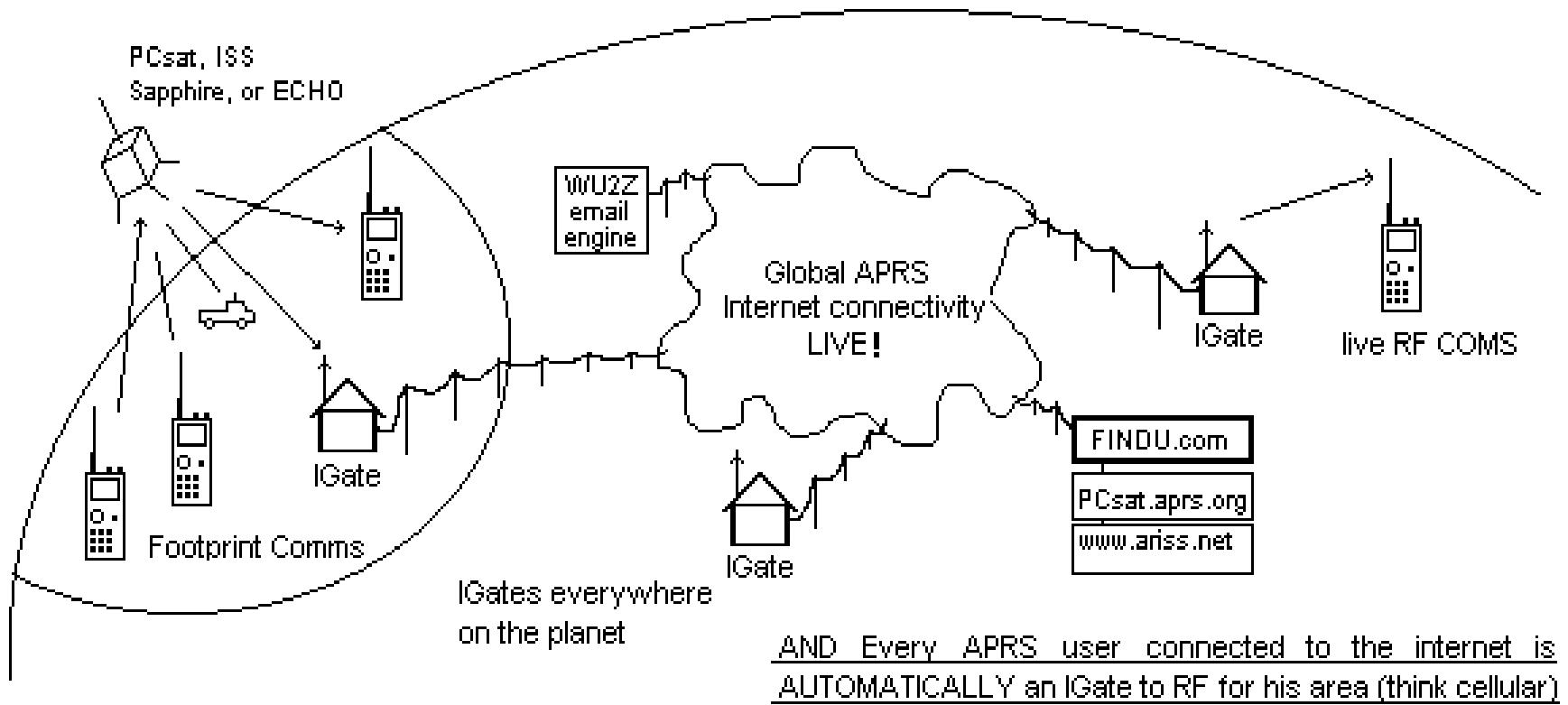
# PCSAT2 Location

**Launch 15 May 2005!    EVA-install 8**



# Global Situational Awareness Network

## Global APRS Real-Time Connectivity ( End-to-End Everywhere )



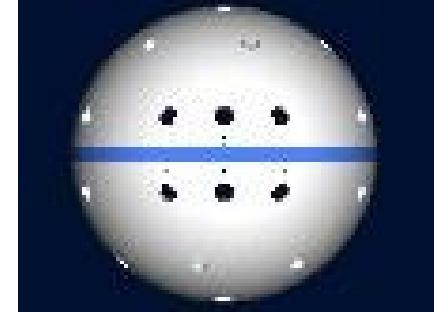
# Typical User Station



Encourage Schools and Students to get involved in Space

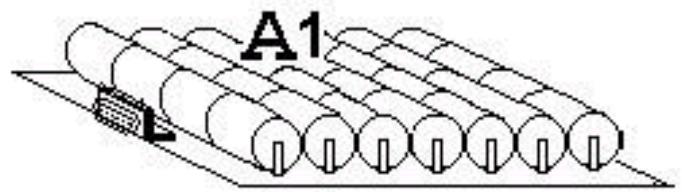
# ANDE Satellite

Joint Project with  
NRL

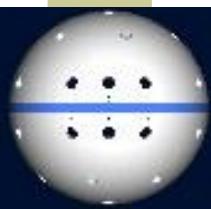


Midn Patterson making SWR measurements outside in full sky.

Atmospheric  
Drag  
USNA Comms  
Telemetry  
- Temperature  
- Attitude  
- Laser  
Control



Primary Lithium  
Batteries

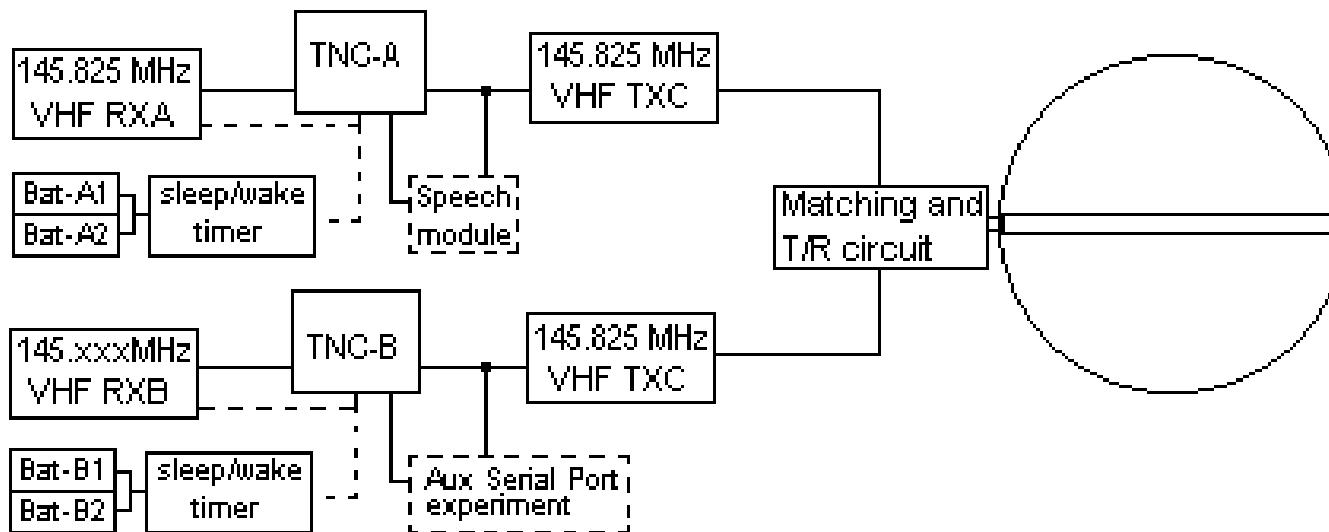


# ANDE Satellite

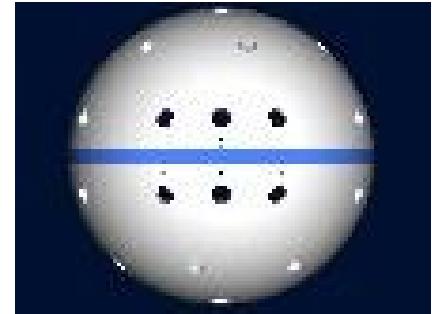


## ANDE COMMS Block Diagram

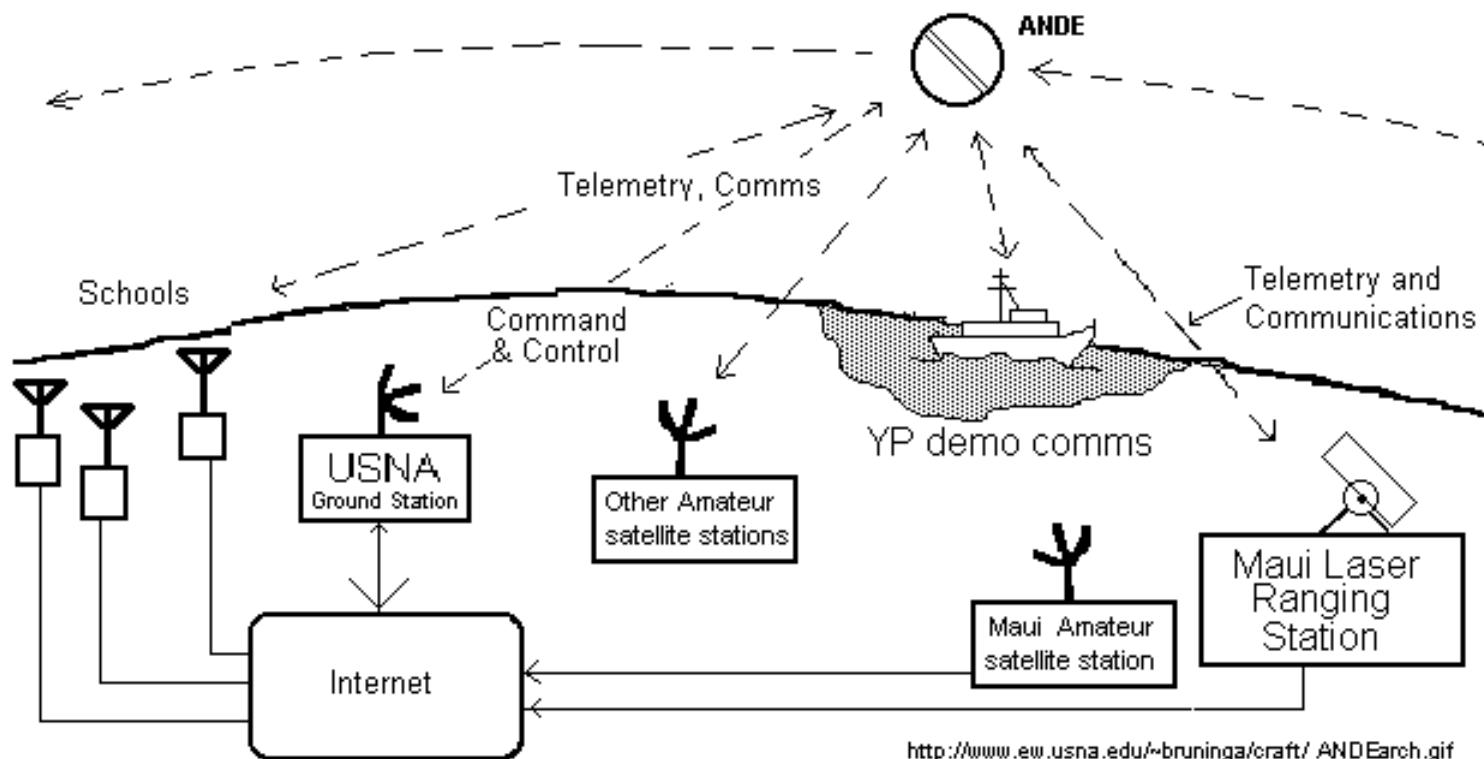
WB4APR



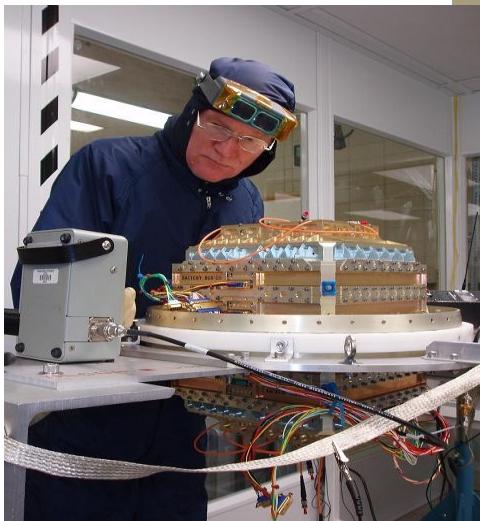
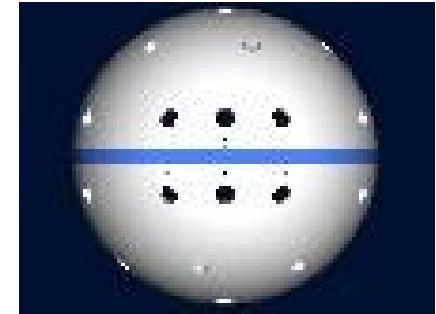
# ANDE Satellite



## ANDE System Architecture



# ANDE Satellite

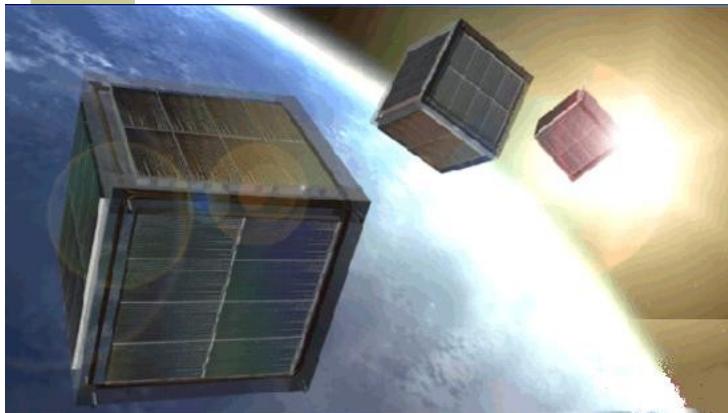


Awaiting  
Launch STS-  
116 Dec 06

# Stanford Cubesat Projects

50 in

construction!

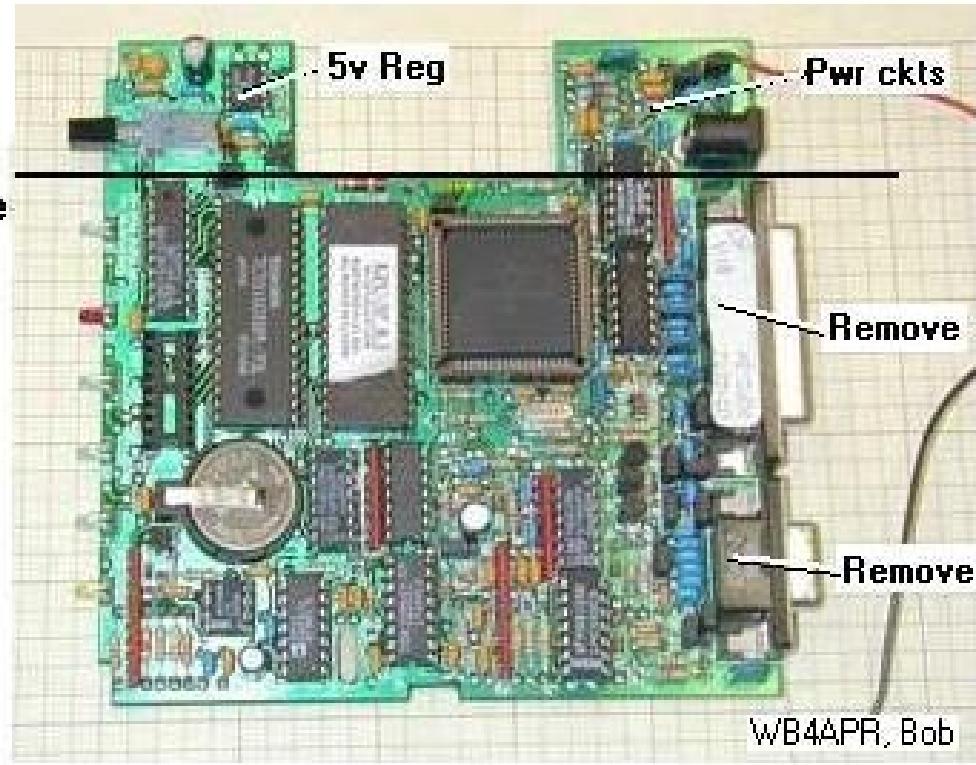
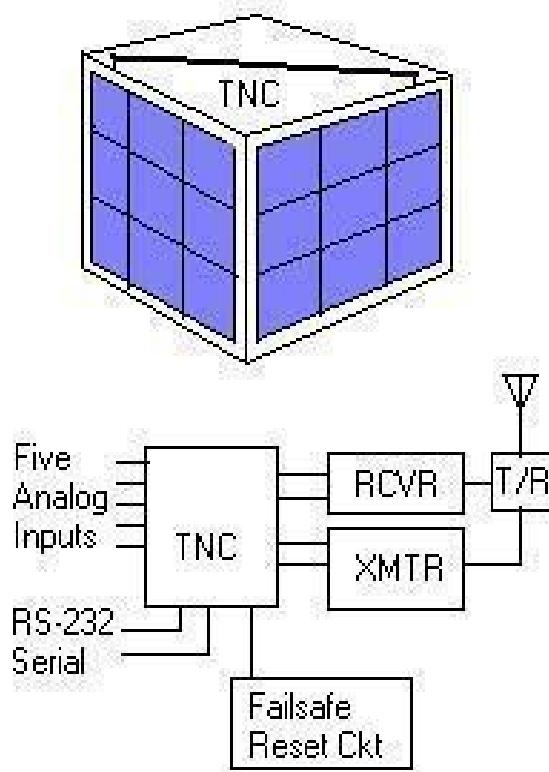


AIAA/US  
U  
Conferen  
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30% of all  
papers  
were  
related to  
CUBESAT  
S

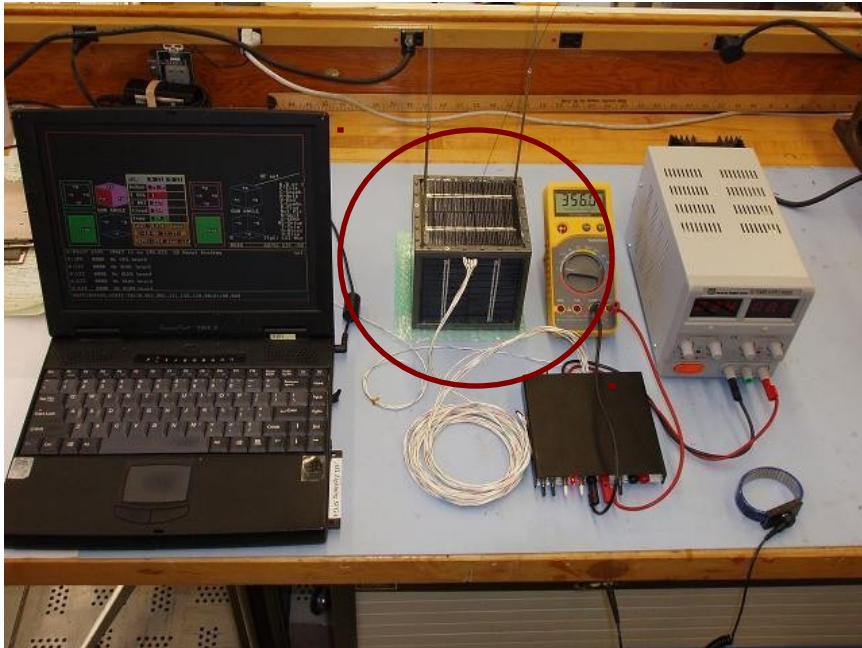


# Simple LABsat TLM/CMD System

(proposed)  
Naval Academy Cubesat with KPC-3+ Digipeater/Telemetry



# RAFT Project (two Satellites)



**NSSS Radar Fence**

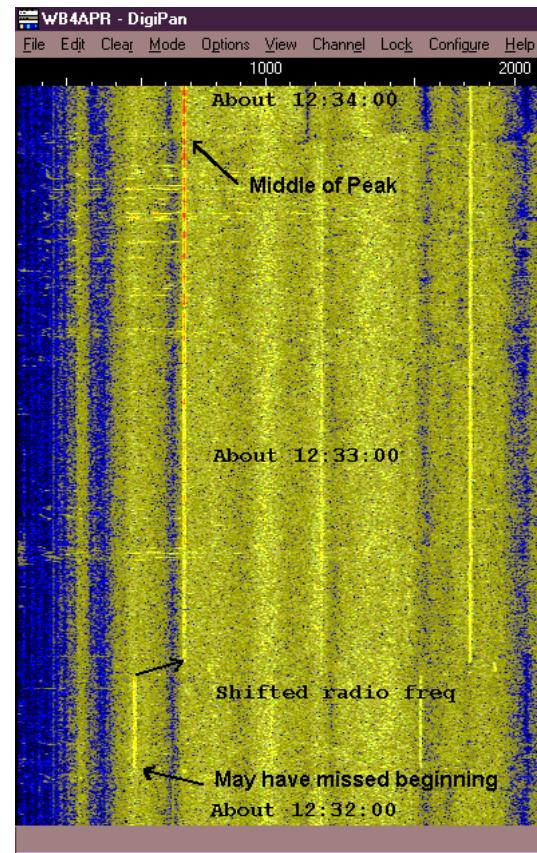
**RAFT-1**  
(~PCsat)

**MARScom**

**216.98**  
**MHz**



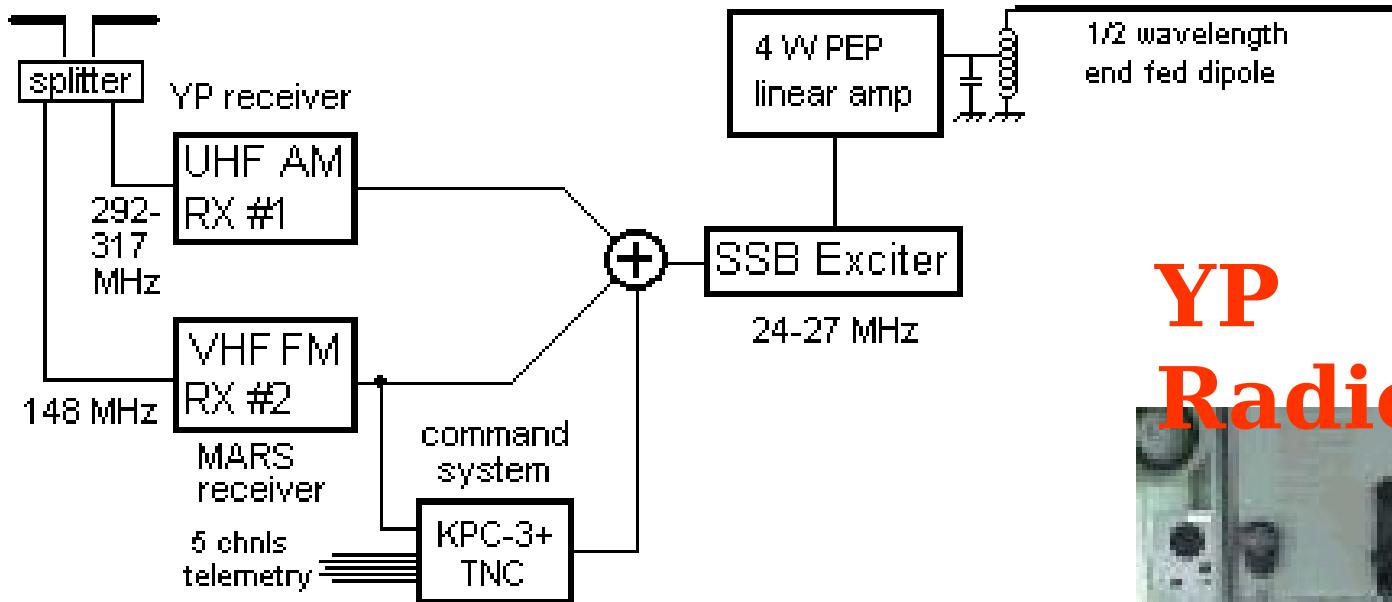
# NAVSPASUR Radar Fence





## MARScom Voice Transponder

VHF/UHF dipole

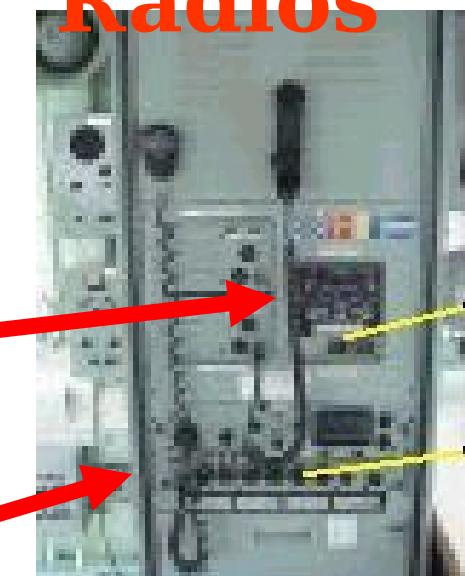


**YP  
Radios**



**UHF AM up**

**HF SSB  
downlink**



# USNA Satellite Lab/Ground Station

Bob Bruninga, Ground Station  
Engineer

- **Satellite and communications Labs**  
PCSAT-1, PCSAT2
- **Satellite Design Projects**  
12 Meter (AO-40)
- **Ground Station Ops**  
C/Ku TVRO (NASA TV)
- **Extracurricular**  
Teleconferencing  
Summer Seminars,  
Tours  
AMSAT Tracking

# PCSAT1/2 Telemetry

# John & Commandin

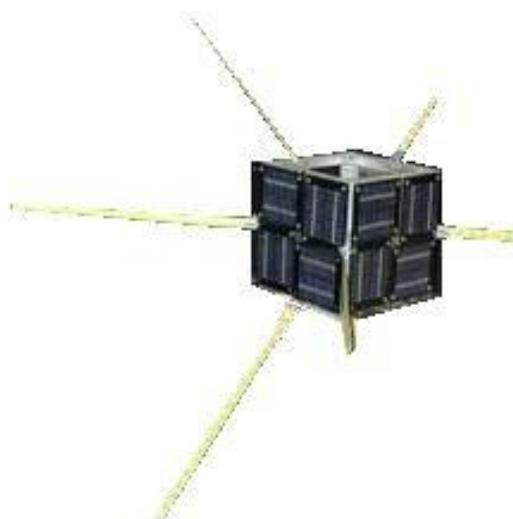
ISIS5/PCSAT2 Telemetry 19:58:56 A027 A2/EL 339 1

Pkt: [13:32:42] PCSAT2>BEACON,SGATE,WIDE:T#010,002,121,001,000,072,11111111,0001,1

BATTERY	Volts	Current mA	Current mA	Temps	Deg C	Frame	Time							
Batry	11	12.7	Solar	11	0	RXA	00	48	RCURS	10	21	00	19:58:54	
Cell1	00	10.66	Batry	11	-128	RXB	00	56	TLM	10	21	4	01	19:58:56
Cell2	10	7.24	Load	11	313	TNGA	00	30	TXA	10	22	7	10	19:58:51
Cell3	01	3.62	Shunt	01	-185	TNGB	00	30	TXB	01	21	4	11	19:58:54
Svolt	11	4.97		01	0	IxA	01	5	PEC	01	29	7		
	01	0		01	0	IxB	01	0	Batry	01	32	1		
LATENCY												LOU-U-SHUNT	COLORS	
COMMAND STATUS: 11111111												Period: 60 secs		
01111	11111	96hr Bit	96hr Bit											
01011	11111	Reset TNC	Toggled other TNC	11	ARM A1	OK.								
11011	11111	RX heaters	RX heaters	01	ARM A2	OK.								
11110	11111	UHF xmtr	UHF xmtr	10	ARM B1	OK.								
11111	01111	Charge Rate	Toggled Charge Rate	00	ARM B2	OK.								
11111	01111	RPT B1	RPT B1											
11111	11011	RPT B2	RPT B2											
11111	11101	RPT B3	RPT B3											
11111	11110	RPT OFF	PSW OFF											
CTRL A	ON	resets FTSC	Hit > for next											
CTRL B	ON	resets 8 hrs												
At Time 13:32:42												TTgo 0		
Rply:3n181328.TLM												FTSC packets 0		
90														
Dtime	1.921875													
30														
10														
0														
AO16 AO10												AO14	N	
K01 S041												W	qs1	
1hr												S		
[13:32:42] PCSAT2>BEACON,SGATE,WIDE:T#010,002,121,001,000,072,11111111,0001,1												E		

It takes 4 packets for a complete telemetry set. White shows the most recent values, Green is 10 seconds old, yellow is 20 seconds old and red is 30 seconds old. This is at the highest rate. Normally PCSAT2 will use 40 seconds for all 4 sets. The upper right FRAME and TIME show the time of each frame.

The middle area of the screen shows the ON/OFF status of the command bits. The bottom shows the elevation of the next 60 minutes of satellite passes. Solid color indicates a pass is occurring.



POWER	A	B
BAT-A	14.66	14.07
BAT-B	14.54	14.09
P-out	1.8	2.09
Reg8v	7.47	7.47
Reg5v	4.98	4.98
<hr/>		
TEMPS	A+	B-
X	-2	3.2
Y	-.6	3.2
Z	-.3	3.2
STACK	1.5	.8
XMTTR	4.9	3.5
BAT	4.2	5.2

A:BText	1213	>211613
A:GPS	0000	No GPS
A:LT1	0000	No BLN1
A:LT2	0000	No BLN2
A:LT3	1216	:BLN3PC
A:LT4	1216	:BLN4PC

I/O		B
BTiso	f	
TXiso	of	
UHF-A	on	on
UHF-B	off	off
GPS	off	off
RESET	off	off
CLR72	off	off
HI/MI	off	off
RADTR	off	off
SYNC	off	off
LAST	1213	1218
10-21-01	12:21:47	

CURNT	A+	A
X	-14	9
Y	8	1
Z	-21	
BAT	178	

## Wire

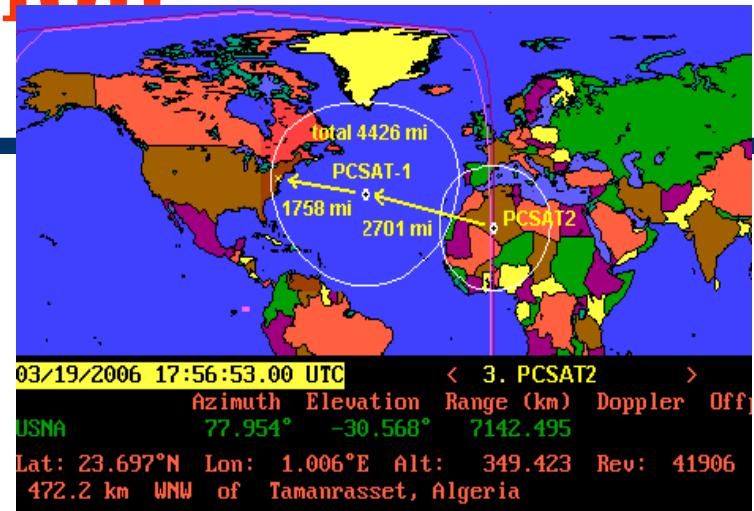
Telemetry screen of PCsat during periods of maximum eclipse cycles (35 mins eclipse, 65 mins of Sun). This snapshot was taken at 1621z on 21 Oct 2001, 20 minutes or (1/3rd) into the Sun. Notice the still cold temperatures. Also notice the low Battery voltage 14 x volts and high charge currents of 178 and 204 mA. Also the UV String experiment is separated.

# USNA Satellite Lab/Ground Station



**ISS commander cheers for Army in contact with Naval Academy's W3ADO (Dec 1, 2005)**

During a brief contact November 26 between the US Naval Academy's W3ADO and NA1SS, ISS Commander Bill McArthur cheered for an Army win "Thanks very much for the contact, but I can't resist," said McArthur, a US Army officer and veteran.  
"Go, Army. Beat Navy!"



**RS0ISS>PP0OPPO,SGATE,qAo: Go Army beat Navy!**

**PCSAT-1>APRS,SGATE,qAo: Go Navy Beat Army!**

Alternating ISS Pass Geometries for US Naval Academy at 39°N latitude  
PCSAT2>APRS,SGATE,qAo: Go Navy  
Beat Army!



Two excellent overhead passes per day (2,6)  
Four OK passes up to 10 deg (1,3,5,7). This pattern occurs every other day.



Four good 30 degree passes per day (2,3,6,7).  
Four very low <5 deg passes per day (1,4,5,8).  
Pattern occurs every other day.

WB4APR

During the March 2006 joint PC1=>PC2 operations period, numerous dual hop telemetry and user packets were observed. This telemetry packet from PCSAT2 is just about as far as we can get with satellite-to-satellite-to-USNA. Notice how few European or USA users were in the footprint making it more probable that PCSAT-1 could hear PCSAT2's signal. WB4APR

# USNA Satellite Lab/Ground Station

Bob Bruninga, Ground Station  
Engineer

- Satellite and communications Labs
- Ground Station Ops
- Satellite Design Projects
- Extracurricular



# Other Activities



**Space Day  
(Air&Space)**

**AMSAT (North  
America)**

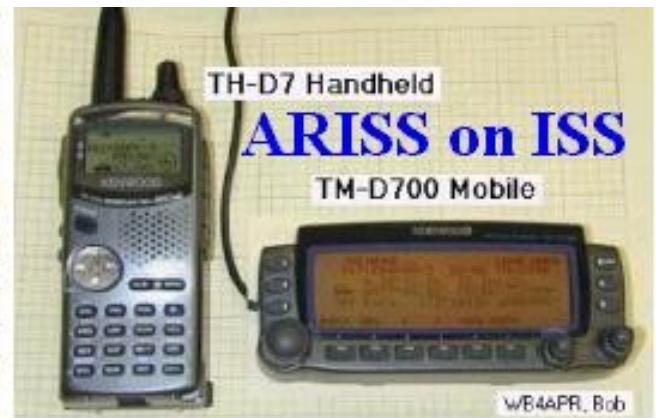
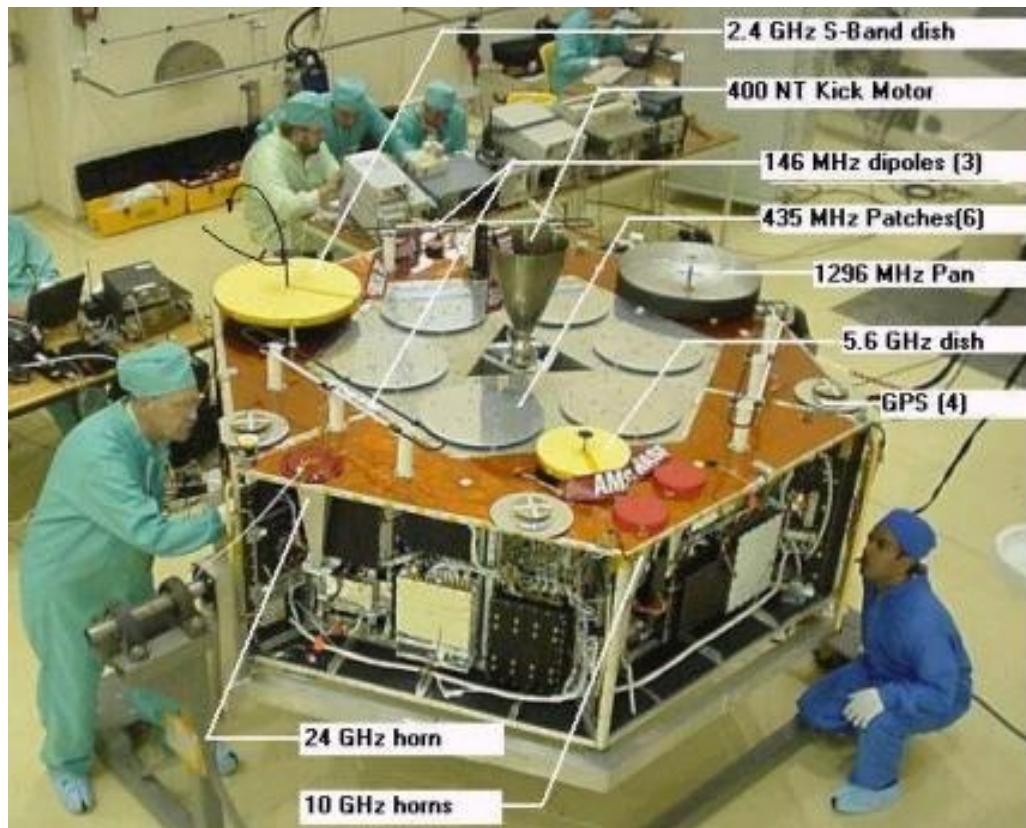
**Marconi 100<sup>th</sup> (St  
Johns)**

**BSA RadioBadge  
School Mentoring**

**Balloon Tracking**

# AMSAT Operations

## AO-40 Rescue



## Satellite Tracking:

- **UO-14, UO22**
- **FO-20, FO-29**
- **NO-44, NO-45**
- **PCSAT2**

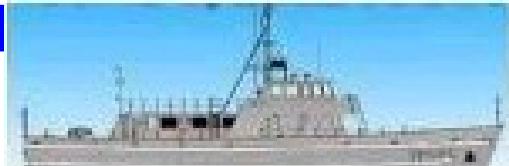
# USNA Extracurricular Activities

W3ADO, oldest USNA ECA  
(1928)

## Annual Moonbounce Event



## Football & Boat GPS Tracking, Comms, Internet Sea Trials



Imagry